



Office Action Summary

Application No.

09/900,861

Applicant(s)

LIANG ET AL.

Examiner

Hanh Phan

Art Unit

2633

- The MAILING DATE of this communication appears on the cover sheet with the correspondence address -

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 10 July 2001.
- 2a) ☐ This action is FINAL.
- 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-18 is/are pending in the application.
 - 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-18 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a). Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 - a) ☐ All b) ☐ Some * c) ☐ None of:
 - 1. ☐ Certified copies of the priority documents have been received.
 - 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 - 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

RECEIVED
AUG 03 2004
Technology Center 2600



07/27/04

2633

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Response
8/15/04
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Att: Mr. Hanh Phan
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AUG 03 2004

Technology Center 2600

Tel: (703) 306-5840

Application/Control Number: 09/900,861; Art Unit 2633

July 26, 2004

Dear Mr. Hanh Phan,

Thank you very much for your comments on our patent application "METHOD TO IMPROVE THE PERFORMANCE OF FIBER TRANSMISSION SYSTEMS BY TRANSFORMING RETURN-TO-ZERO FORMAT TO NON-RETURN-TO-ZERO FORMAT IN FRONT OF RECEIVER". We have corrected our applications according to your comments. In the revised application, we try to limit the claims to only for one kind pulse transformer which takes advantage of very high nonlinear effect in a normal dispersion fiber. Here are some explanations to address your comments:

1. For your comment 5, quote: "Claims 1-5 and 7-16 are rejected under 35 U.S.C. 103 (a) as being unpatentable over Charplyvy (Pub. No. US 2003/0007216 A1) in view of Pruncnal et al (US Patent No. 6,448,913)."

There are many dispersion managed RZ systems which include Charplyvy's DPSK systems, dispersion managed soliton and chirped RZ systems etc. (see M. Suzuki, et al., "Reduction of Gordon Haus timing jitter by periodic dispersion compensation in soliton transmission", Electron. Lett., vol. 31, 1995, pp. 2027-2029; N. Bergano, et al, " 640 Gb/s transmission of sixty-four 10 Gb/s WDM channels over 7200 km with 0.33 (bits/s)/Hz spectral efficiency", OFC'99, 21-26 Feb., 1999, paper PD2.), however, as

you noticed, the RZ pulses in these RZ systems have not been transformed to NRZ pulses which are detected receivers finally. Our invention is to put an optical pulse transformer (i.e. data format converter), which takes advantage of very high nonlinear effect in a normal dispersion fiber, in between the transmission link and receiver, and it can improve the system performance-Q factor significantly (e.g. 5.4 dB in our experiment) by transforming the RZ pulses to NRZ or quasi-NRZ pulses. Although Pruncnal et al proposed a data format converter to transform the RZ pulses to NRZ or quasi-NRZ pulses, their converter really is degrading instead of improving system performance as shown in their experiments (see Pruncnal et al. US Patent No. 6,448,913; and L. Xu, B. C. Wang, V. Baby, I. Glesk, P. R. Pruncnal, "All-optical data format conversion between RZ and NRZ based on a Mach-Zehnder interferometric wavelength converter", IEEE Photonics Technol. Lett., Vol. 15, N. 2, 2003, pp. 308-310). In more detail, Pruncnal et al's patent differs fundamentally from this invention in following aspects:

(1). Pruncnal et al's patent for transferring RZ to NRZ degrades the system performance seriously instead of improving it, while the present invention improves the Q (i.e. system performance) by at least 5.4 dB. The experimental results described in the paper written by Pruncnal et al shows that their technique has at least 7 dB of Q penalty or 12 dB of power penalty (see Fig. 5 of L. Xu, B. C. Wang, V. Baby, I. Glesk, P. R. Pruncnal, "All-optical data format conversion between RZ and NRZ based on a Mach-Zehnder interferometric wavelength converter", IEEE Photonics Technol. Lett., Vol. 15, N. 2, 2003, pp. 308-310.). Contrary to their result, our experiment using the present invention demonstrates an increase of the Q factor by 5.4 dB, which is a significant improvement on system performance (see M. Suzuki, H. Toda, A. Liang, & A. Hasegawa, "Improvement of Amplitude and Phase Margins in an RZ Optical Receiver using Kerr Nonlinearity in Normal Dispersion Fiber", IEEE Photonics Technol. Lett., Vol. 13, 2001, pp. 1248-1250.).

(2). Pruncnal et al's patent is not suitable for the data transformer application just in front of receiver, because their invention degrades the performance instead of improving the performance (however, their patent may be useful in other applications,

e.g. wavelength conversion), but our optical pulse transformer is useful for the application in front of receiver.

(3). Although they claim their patent is a RZ to NRZ pulse transformer, their original patent is actually only for RZ pulse broadening, and the RZ pulse does not change to NRZ pulse or even rectangular or flat-top pulse at all as can be seen from Fig. 3 in their patent (see Prucnal et al., Sept., 2002, US Pat. No. 6,448,913 B1) and Fig. 2 in their paper (see L. Xu, B. C. Wang, V. Baby, I. Glesk, P. R. Prucnal, "All-optical data format conversion between RZ and NRZ based on a Mach-Zehnder interferometric wavelength converter", IEEE Photonics Technol. Lett., Vol. 15, N. 2, 2003, pp. 308-310.). In their experiments, their so called "NRZ pulse" is really RZ pulse with very low duty ratio. They need to use the pulse duplicator to duplicate the RZ pulse at first to get the real NRZ pulses (as shown in their paper in 2003), but they did not have the duplicator in their granted patent in 2001.

(4). Even with a pulse duplicator, the generated NRZ pulses in their experiment have much larger amplitude ripples than those of our invention (compare Fig. 4 (b) of L. Xu, B. C. Wang, V. Baby, I. Glesk, P. R. Prucnal, "All-optical data format conversion between RZ and NRZ based on a Mach-Zehnder interferometric wavelength converter", IEEE Photonics Technol. Lett., Vol. 15, N. 2, 2003, pp. 308-310, to Fig. 4 of M. Suzuki, H. Toda, A. Liang, & A. Hasegawa, "Improvement of Amplitude and Phase Margins in an RZ Optical Receiver using Kerr Nonlinearity in Normal Dispersion Fiber", IEEE Photonics Technol. Lett., Vol. 13, 2001, pp. 1248-1250). In the present invention, the amplitude fluctuation of the generated NRZ pulses is very small and even smaller than the input bell shape RZ pulses, because of the nonlinear effect (the nonlinear clamping), which is induced from the high self-phase modulation in the normal dispersion fibers.

(5). Their patent is inappropriate for high bit rate pulses because of slow carrier recovery time of semiconductor optical amplifier (SOA) (around 180- 250 ps typically). In their format conversion patent, there is a trade off for the SOA carrier recovery time, which should be long enough to get a flat top on the converted NRZ pulses and short enough to reduce pattern-dependent effects and to get sharp rising and falling edges on the converted pulses (see Fig. 4 (b) of L. Xu, B. C. Wang, V. Baby, I. Glesk, P. R. Prucnal, "All-optical data format conversion between RZ and NRZ based on a Mach-

Zehnder interferometric wavelength converter", IEEE Photonics Technol. Lett., Vol. 15, N. 2, 2003, pp. 308-310.). Therefore their schemes on format conversion are good only for 1-5 Gbit/s, no 10 Gbit/s or higher bit rate converters have been demonstrated. On the contrary, the present invention works well for 10, 40 Gbit/s and higher bit rate format conversion; we have demonstrated the 10 Gbit/s format conversion.

(6). The optical pulse transformer in their invention is more complex and expensive than that in our invention.

(7). The optical pulse transformer in their invention can not be used for multiple wavelengths because of the cross gain modulation of SOAs; the cross gain modulation is one of the main obstacles to use SOAs in WDM/DWDM systems. The optical pulse transformer in present invention can be used for multiple wavelengths at the same time as long as the channel spacing is large enough. Therefore, it will further reduce our cost significantly.

2. For your comment 6, quote: "Claim 6 and 18 are rejected under U.S.C. 103 (a) as being unpatentable over Charplyvy et al ...further in view of Golovchenko et al (US patent No. 6,243,181)."

In Golovchenko's et al patent, the normal dispersion fibers are used as inline dispersion compensation in the transmission lines as many other people do (see also M. Suzuki, et al., "Reduction of Gordon Haus timing jitter by periodic dispersion compensation in soliton transmission", Electron. Lett., vol. 31, 1995, pp. 2027-2029; N. J. Doran et al., "Remarkable Feature of DM Solitons: Implications for high speed and WDM systems", in *New Trends in Optical Soliton Transmission Systems*, Ed. By A. Hasegawa., Kluwer Academic Publishers, 1997, pp. 303-316.), and mainly the linear dispersion effect of their normal dispersion fibers is used and the RZ pulses have not been transformed into NRZ pulses in the normal dispersion fibers. However, in our transformer, very high nonlinear effect has been used to change the pulses from RZ to NRZ or quasi-NRZ and the nonlinear clamping effect has been used also. After their dispersion managed links, there are still some amplitude and timing jitters left, so our transformer can be used to reduce these jitters further. In more detail, Golovchenko's et al patent differs fundamentally from this invention in following aspects:

In our optical pulse transformer, the transmitted RZ pulses are first amplified by an optical amplifier then launched into the normal dispersion fibers. The launched RZ pulses have very high power, which can be equivalent to the power of many higher order solitons (i.e. $N \gg 1$) in normal dispersion region, where N^2 , which equals Dispersion Length/Nonlinear Length, increases with power and decreases with dispersion of fiber. The launched high power bell shape RZ pulses as they propagate along the normal dispersion fibers with Kerr effect, their temporal waveforms change to a rectangular or flat top pulses (i.e. quasi- NRZ pulses) with steep leading and trailing edges (See G. P. Agrawal, *Nonlinear Fiber Optics*, Academic Press, pp. 102-111, 1995). In our experiment, the launched RZ pulses have as high as 10 - 13^{th} of equivalent soliton order in a normal dispersion fiber. Our experiment demonstrated that the optical pulse transformer not only increases the generalized timing jitter tolerance but also reduces the amplitude fluctuation and the ISI influence, so it enables us to have larger phase and amplitude margins (see M. Suzuki, H. Toda, A. Liang, & A. Hasegawa, "Improvement of Amplitude and Phase Margins in an RZ Optical Receiver using Kerr Nonlinearity in Normal Dispersion Fiber", *IEEE Photonics Technol. Lett.*, Vol. 13, 2001, pp. 1248-1250.). As shown in Fig. 9, our experiment shows that the amplitude fluctuations, which mainly comes from the pulse interactions and ASE noise, of converted flat-top quasi-NRZ pulses are pretty small and are even smaller than the original amplitude fluctuations of transmitted RZ pulses, we identify this phenomena as the nonlinearity clamping that occurs in normal dispersion region for pulses having a large power (See K. Tai, A. Hasegawa, and A. Tomita, *Phys. Rev. Lett.*, vol. 56, 1986, pp. 135-137.). We note that the role, mechanics and locations for the normal dispersion fiber in our optical pulse transformer differs from those in dispersion managed RZ and NRZ systems. In dispersion managed RZ and NRZ systems (e.g. dispersion managed soliton, CRZ, CS-RZ systems etc.), the normal dispersion fibers, which are used in each span or several spans of a transmission link, are used as in line dispersion compensators to compensate for the anomalous dispersion of transmission fibers and reduce the timing jitter and amplitude jitter influence induced from four-wave-mixing and cross-phase modulations (See

Golovchenko et al, US Patent 6,243,181 B1; M. Suzuki, et al., "Reduction of Gordon Haus timing jitter by periodic dispersion compensation in soliton transmission", *Electron. Lett.*, vol. 31, 1995, pp. 2027-2029; N. J. Doran et al., "Remarkable Feature of DM Solitons: Implications for high speed and WDM systems", in *New Trends in Optical Soliton Transmission Systems*, Ed. By A. Hasegawa., Kluwer Academic Publishers, 1997, pp. 303-316.). In all these dispersion managed systems, the nonlinear effect in the normal fibers is always weak (i.e. the equivalent soliton order N is always less than one and is typically much less than one because of relative low optical power), and the linear dispersion effect is the dominant effect. However in the normal dispersion fiber of our optical pulse transformer, the nonlinear effect is dominant and is very strong (i.e. the equivalent soliton order N is much larger than one because of very high optical power), and the linear dispersion effect only plays a minor role. For example, in our experiment, the equivalent soliton order is as high as 10-13 for the launched high power pulses. In the normal dispersion fibers of all their systems, the RZ pulses are not transformed to NRZ or quasi-NRZ pulses as those in our transformer are. The normal dispersion fibers of our optical pulse transformer are located after the transmission link, which can be a dispersion managed link, but not in the transmission link as in line dispersion compensation fibers like those in other people's dispersion managed systems. After RZ pulses transmitting over their dispersion managed link, there are normally still a lot of amplitude and timing jitters left, so our pulse transformer can be used to further reduce the left amplitude and timing jitters and improve the Q further. In some transmission systems, where the normal dispersion fibers are used as the post dispersion compensation, primarily the linear dispersion effect, instead of the nonlinear effect, is used. The linear dispersion effect in our pulse transformer only plays very little role to compensate the residual dispersion of the whole transmission link, and the nonlinear effect plays major role in reducing the influences of timing jitters and amplitude jitter. For example, in our experiment for the 10 Gbit/s soliton transmission, the dispersion and length for transmission fibers are 0.88 ps/km/nm and 12,000 km respectively, and the dispersion and length for the normal dispersion fiber in the transformer are -3 ps/km/nm and 20 km respectively. (see M. Suzuki, H. Toda, A. Liang, & A. Hasegawa, "Improvement of Amplitude and Phase Margins in an RZ Optical Receiver using Kerr Nonlinearity in

Normal Dispersion Fiber", IEEE Photonics Technol. Lett., Vol. 13, 2001, pp. 1248-1250). The total dispersion of normal dispersion fiber in the transformer only compensates the total residual dispersion by about 0.6% (i.e. 60 over 10560 ps/nm).

3. For your comment 7, quote: "Claims 17 is rejected under ... and further in view of Webb (US Patent No. 6,163,394)."

Low pass electrical filter and decision circuit have been widely used in receivers of optical systems over several tens of years, neither us nor Webb are new to use the low pass filter. In our invention, we just need to optimize the filter bandwidth according to our pulse and spectrum shapes from our pulses transformer.

Please find the enclosed hard copy and e-version in the floppy disk! I have also enclosed two papers for your references, where one is published by Prucnal's group and one is published by us. You can compare their experimental results with our experimental results carefully, and you can easily find that our invention can really improve the system performance but their invention can not.

If you have any questions, you are welcome to give me a call (408-316-2556).

I hope this application can be approved after this revision!

Thank you very much for your comments!

Best Wishes!

Sincerely



Anhui Liang